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Patent
TS-6377 (US)
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Del S. Christensen

Date: January 29, 2004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	
Johannis Josephus Den Boer et al.	
Serial No. 10/621,823	Group Art Unit: NA
Filed July 17, 2003	Examiner: NA
FORGE WELDING OF HEAVY DUTY TUBULARS	Date: January 8, 2004

COMMISSIONER FOR PATENTS
Alexandria, VA 22313-1450

Sir:

CLAIM TO PRIORITY

Applicant(s) reaffirm the claim for the benefit of filing date of the following foreign patent application referred to in Applicant's Declaration:

European Application Serial No. 02077913.8 filed July 17, 2002.

A copy of the application certified by the European Patent Office is enclosed.

Respectfully submitted,

Johannis Josephus Den Boer et al.

By

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Attachment

TS 6377 USA

Eur päisches Patentamt | European Patent Office | Office eur péen des brevets

Bescheinigung | Certificate | Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

02077913.8

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

Anmeldung Nr:
Application no.: 02077913.8
Demande no:

Anmeldetag:
Date of filing: 17.07.02
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Forge welding of heavy duty tubulars

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
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B23K20/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

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TS 6377 EPC

Peb

FORGE WELDING OF HEAVY DUTY TUBULARS

Background of the Invention

The invention relates to an improved method for forge welding of heavy duty tubulars such that a welded connection of high strength and quality is obtained. Heavy duty tubulars may be formed by oilfield, well and/or other tubulars which are in use subject to high mechanical and/or thermal stresses as a result of their use in an irregular borehole or hostile on- or offshore environment. Thus the heavy duty tubulars may frequently be subject to large radial, tangential and/or shear stresses which cause a high elastic, plastic and/or pseudo plastic deformation of the tubular wall and any tubular joints. The heavy duty tubulars may be tubulars which are expanded downhole to a larger diameter and plastically deformed during the expansion process, drill pipes which may be 10 kilometers long and twisted over 30 times of the pipe circumference as a result of the torque transmitted to the drill bit and friction between the drill pipe and the irregular borehole wall or heater well casings, steam injection and/or other heater pipes which are subject to high thermal expansion and may be squeezed by the thermal expansion of the surrounding formation and/or subsidence during the production operations.

Forge welding involves circumferential heating of the pipe ends that are to be joined and subsequently pressing the pipe ends together to form a metallurgical bond.

A large variety of heating technologies may be used to make the pipe ends hot enough such that the

metallurgical bond can be made. The heating techniques may involve electric, electromagnetic, induction, infrared, sparking and/or friction heating or combinations of these and other heating methods.

When used in this specification the term forge welding is intended to encompass all techniques which involve circumferential heating of pipe ends and subsequent metallurgical bonding the heated pipe ends, including welding techniques that are generally known as diffusion welding, friction welding, flash welding and/or butt welding.

It is known from US patents 4,566,625 ; 4,736,084 ; 4,669,650 and 5,721,413 issued to Per H. Moe that it may be beneficial to flush the pipe ends just before and during the forge welding operation with a reducing flushing gas, such as hydrogen or carbon monoxide, such that any oxygen skin is removed from the heated pipe ends and a metallurgical bond with a minimal amount of irregularities is obtained. It is also known from US patents 2,719,207 and 4,728,760 to use non explosive mixtures comprising about 95% by volume of a substantially insert gas, such as argon, nitrogen and/or helium, and about 5% by volume of a reducing gas, such as hydrogen and/or carbon monoxide for flash welding and induction butt welding.

Experiments have shown that forge welding techniques are capable to generate high quality metallurgical bonds between the tubular ends, in particular if the pipe end are flushed with a reducing flush gas mixture during the welding operation.

It is an object to provide a method for forge welding of heavy duty well, oilfield and or other tubulars which is able to generate a forge welded tubular connection in

within a few minutes only and which generates a weld at which the pipe wall in the region of the weld is weakened and/or stiffened only to a minimal extent and optionally such that only a gradual variation of any strength variation occurs in longitudinal direction of the tubulars.

Summary of the Invention

In accordance with the invention there is provided an improved method of joining heavy duty tubulars, the method comprising joining the tubulars by forge welding and flushing a reducing flushing gas around the heated tubular ends during at least part of the forge welding operation such that oxides are removed from the forge welded tubular ends and the amount of oxide inclusions and irregularities between the forge welded tubular ends is limited.

It is preferred that the tubular ends are teethed or have a complementary sinusoidal shape in order to alleviate forces to the forge welded tubular ends during use of the heavy duty tubular string. The teethed or sinusoidal ends may be pressed against each other by moving the tubular end in a longitudinal direction towards each other during the welding process, whilst the circumferential orientation of the tubular ends is controlled such that along the entire circumference a gap of a substantially constant width is present during the heat up phase.

In such case the tubular ends may be heated by passing a high frequency current in circumferential direction through the tubular walls near the tubular ends that are to be joined and wherein the presence of cold spots along the circumference of the heated tubular ends is reduced by arranging a series of longitudinal ferrite

bars around the outer surface of the tubular ends and/or within the interior thereof. Furthermore the tubular ends may be heated by passing high frequency electrical current through the tubular ends by means of a series of electrodes which are pressed against the inner and/of outer surface of the tubular end adjacent to the tips of the teeth and/or sinusoidal end faces.

The flushing gas may be a non-explosive mixture of a substantially inert gas and a reducing gas, more in particular, the flushing gas comprises more than 90% by volume of a substantially inert gas, such as nitrogen, helium or argon and more than 2% by volume of hydrogen.

The heavy duty tubular string may be a casing while drilling string which carries a drill bit while drilling the hole and which remains in the borehole in an expanded or unexpanded configuration after completion of the drilling process.

The tubulars may also be joined downhole by forge welding after a tube expansion operation wherein a spear is inserted into the region of the tubular ends which then heats the tubular end to a forge welding temperature and presses them together the spear flushes a reducing flushing gas around the heated tubular ends during at least part of the forge welding operation.

In such case the ends of the tubulars may at least partly overlap each other and the spear and or other forge welding device is inserted into the inner tubular which heats up the tubular end, flushes a reducing flushing gas into any gap remaining between the overlapping tubular ends and which subsequently presses the outer surface of the heated end of the inner tubular against the inner surface of the outer tubular to join said tubular ends by forge welding

In such case the partially overlapping tubular ends are preferably teethed or have a complementary sinusoidal shape in order to alleviate the presence of abrupt stress variations to the forge welded expanded tubular ends when the tubular string is bent, compressed and/or otherwise deformed.

Description of Embodiments

The invention will be described in more detail and by way of example with reference to the accompanying drawings Fig: 1 shows two pipe ends (1),(2) with complementary teethed end faces. (3). The teethed end faces can be used to align the tubulars in angular direction.

Fig: 2 show two pipe ends (4),(5) with complementary non-planar end-faces in this case of a sinusoidal shape (6).

Welding of the pipe ends together along the length of the contour of the non-planar end face provides a total length of the weld which is larger than the total circumferential length of the pipes and thereby reduces the loading of the weld compared to that of the pipe body.

Fig: 3 shows two pipe ends (7) and (8) which are partly overlapping. The inner lower pipe end (8) is provided with a non-planar sinusoidal end face which is in contact with the outer pipe (7). Welding of the pipes (7) and (8) together along the non-planar end face of pipe (8) yields a weld length which is larger than the length of the circumference of the outer pipe and thereby reduces the loading of the weld compared to that of the pipe bodies. In addition, this configuration yields a gradual transfer of the loading from one pipe body to the other pipe body and supports the mitigation

of stress concentrations in the overlap zone of the pipes.

C L A I M S

1. A method of joining heavy duty tubulars, the method comprising joining the tubulars by forge welding and flushing a reducing flushing gas around the heated tubular ends during at least part of the forge welding operation such that oxides are removed from the forge welded tubular ends and the amount of oxide inclusions and irregularities between the forge welded tubular ends is limited.

2. The method of claim 1, wherein the tubular ends have a complementary non-planar shape in order to alleviate forces to the forge welded tubular ends during use of the heavy duty tubular string.

3. The method of claim 1, wherein the flushing gas is a non-explosive mixture of a substantially inert gas and a reducing gas.

4. The method of claim 3, wherein the flushing gas comprises more than 90% by volume of a substantially inert gas, such as nitrogen, helium or argon and more than 2% by volume of hydrogen.

5. The method of any one of claims 1-4, wherein the heavy duty tubular string a casing while drilling string which carries a drill bit while drilling the hole and which remains in the borehole in an expanded or unexpanded configuration after completion of the drilling process.

6. The method of claim 2, wherein the tubular ends are heated by passing a high frequency current in circumferential direction through the tubular walls near the tubular ends that are to be joined and wherein the

presence of cold spots along the circumference of the heated tubular ends is reduced by arranging a series of longitudinal ferrite bars around the outer surface of the tubular ends and/or within the interior thereof.

7. The method of claim 6, wherein the tubular ends by passing high frequency electrical current through the tubular ends by means of a series of electrodes which are pressed against the inner and/of outer surface of the tubular end adjacent to the tips of the teeth and/or sinusoidal end faces.

8. The method of claim 1, wherein the tubulars are joined downhole by forge welding after a tube expansion operation and the tubular ends are heated to a forge welding temperature and pressed together whilst a reducing flushing gas is flushed around the heated tubular ends during at least part of the forge welding operation.

9. The method of claim 8, wherein the ends of the tubulars at least partly overlap each other and a forge welding device is inserted into the inner tubular which heats up the tubular end, flushes a reducing flushing gas into any gap remaining between the overlapping tubular ends and which subsequently presses the outer surface of the heated end of the inner tubular against the inner surface of the outer tubular to join said tubular ends by forge welding.

10. The method of claim 9, wherein the partially overlapping tubular ends are teethed or have a complementary sinusoidal shape in order to alleviate forces to the forge welded expanded tubular ends.

A B S T R A C T

FORGE WELDING OF HEAVY DUTY TUBULARS

A method of joining heavy duty oilfield. well, or other tubulars comprises joining the tubulars by forge welding and flushing a reducing flushing gas around the heated tubular ends during at least part of the forge welding operation such that oxides are removed from the forge welded tubular ends and the amount of oxide inclusions and irregularities between the forge welded tubular ends is limited. The tubular ends may have a teethed or complementary non-planar shape to inhibit any abrupt variations of the wall strength in the welding area and/or to reduce shear forces to the forge weld when the tubulars are twisted and/or radially expanded.

(Fig.1)

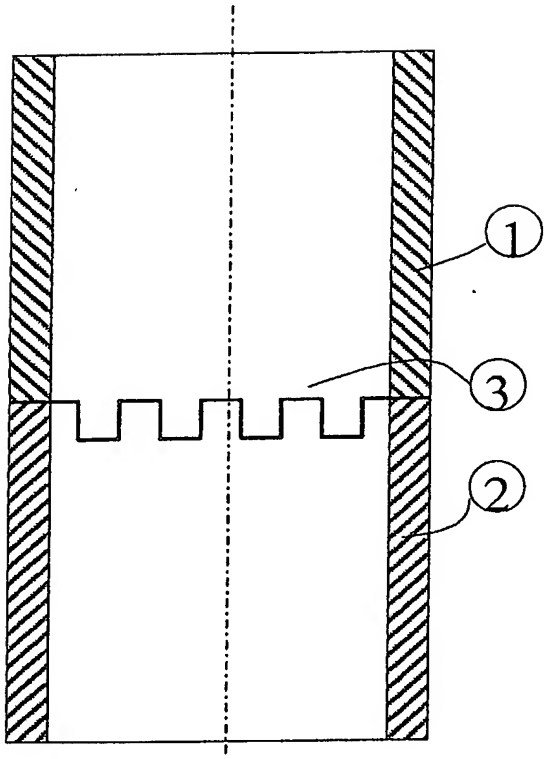

Fig 1

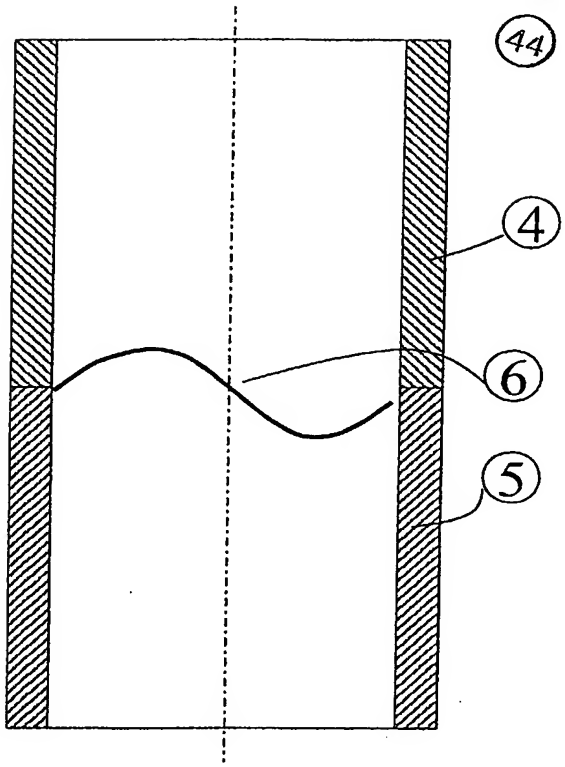

Fig 2

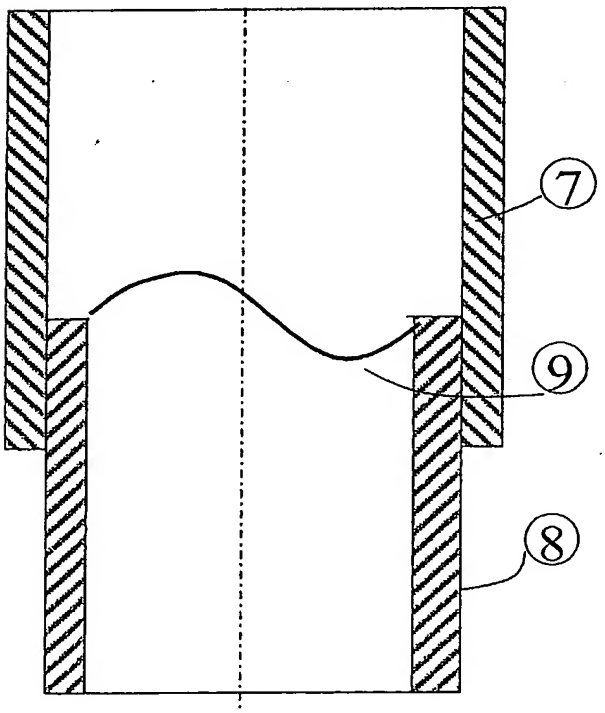

Fig 3